

SOLUBILITY OF SELECTED GASES IN WATER

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The values in this table are taken almost exclusively from the International Union of Pure and Applied Chemistry "Solubility Data Series". Unless noted, they comprise evaluated data fitted to a smoothing equation. The data at each temperature are then derived from the smoothing equation which expresses the mole fraction solubility X_1 of the gas in solution as:

$$\ln X_1 = A + B/T^* + C \ln T^*$$

where

$$T^* = T/100 \text{ K}$$

All values refer to a partial pressure of the gas of 101.325 kPa (one atmosphere).

The equation constants, the standard deviation for $\ln X_1$ (except where noted), and the temperature range over which the equation applies are given in the column headed Equation constants. There are two exceptions. The equation for methane has an added term, DT^* . The equation for H_2Se and H_2S takes the form,

$$\ln X_1 = A + B/T + C \ln T + DT$$

where T is the temperature in kelvin.

Solubilities given for those gases which react with water, namely ozone, nitrogen oxides, chlorine and its oxides, carbon dioxide, hydrogen sulfide, hydrogen selenide and sulfur dioxide, are recorded as bulk solubilities; i.e., all chemical species of the gas and its reaction products with water are included.

Gas	T/K	Solubility (X_1)	Equation constants	Ref.
Hydrogen (H_2) $M_r = 2.01588$	288.15	1.510×10^{-5}	$A = -48.1611$	1
	293.15	1.455×10^{-5}	$B = 55.2845$	
	298.15	1.411×10^{-5}	$C = 16.8893$	
	303.15	1.377×10^{-5}	Std. dev. = $\pm 0.54\%$	
	308.15	1.350×10^{-5}	Temp. range = 273.15–353.15	
Deuterium (D_2) $M_r = 4.0282$	283.15	$1.675 \times 10^{-5} \pm 0.57\%$	Averaged experimental values	1
	288.15	$1.595 \times 10^{-5} \pm 0.57\%$		
	293.15	$1.512 \times 10^{-5} \pm 0.78\%$	Temp. range = 278.15–303.15	
	298.15	$1.460 \times 10^{-5} \pm 0.52\%$		
	303.15	$1.395 \times 10^{-5} \pm 0.37\%$		
Helium (He) $A_r = 4.0026$	288.15	7.123×10^{-6}	$A = -41.4611$	2
	293.15	7.044×10^{-6}	$B = 42.5962$	
	298.15	6.997×10^{-6}	$C = 14.0094$	
	303.15	6.978×10^{-6}	Std. dev. = $\pm 0.54\%$	
	308.15	6.987×10^{-6}	Temp. range = 273.15–348.15	
Neon (Ne) $A_r = 20.1797$	288.15	8.702×10^{-6}	$A = -52.8573$	2
	293.15	8.395×10^{-6}	$B = 61.0494$	
	298.15	8.152×10^{-6}	$C = 18.9157$	
	303.15	7.966×10^{-6}	Std. dev. = $\pm 0.47\%$	
	308.15	7.829×10^{-6}	Temp. range = 273.15–348.15	
Argon (Ar) $A_r = 39.948$	288.15	3.025×10^{-5}	$A = -57.6661$	3
	293.15	2.748×10^{-5}	$B = 74.7627$	
	298.15	2.519×10^{-5}	$C = 20.1398$	
	303.15	2.328×10^{-5}	Std. dev. = $\pm 0.26\%$	
	308.15	2.169×10^{-5}	Temp. range = 273.15–348.15	
Krypton (Kr) $A_r = 83.80$	288.15	5.696×10^{-5}	$A = -66.9928$	4
	293.15	5.041×10^{-5}	$B = 91.0166$	
	298.15	4.512×10^{-5}	$C = 24.2207$	
	303.15	4.079×10^{-5}	Std. dev. = $\pm 0.32\%$	
	308.15	3.725×10^{-5}	Temp. range = 273.15–353.15	
Xenon (Xe) $A_r = 131.29$	288.15	10.519×10^{-5}	$A = -74.7398$	4
	293.15	9.051×10^{-5}	$B = 105.210$	
	298.15	7.890×10^{-5}	$C = 27.4664$	
	303.15	6.961×10^{-5}	Std. dev. = $\pm 0.35\%$	
	308.15	6.212×10^{-5}	Temp. range = 273.15–348.15	

Gas	T/K	Solubility (X_1)	Equation constants	Ref.
Radon-222(²²² Rn) $M_r = 222$	288.15	2.299×10^{-4}	$A = -90.5481$	
	293.15	1.945×10^{-4}	$B = 130.026$	
	298.15	1.671×10^{-4}	$C = 35.0047$	
	303.15	1.457×10^{-4}	Std. dev. = $\pm 1.02\%$	
	308.15	1.288×10^{-4}	Temp. range = 273.15–373.15	
Oxygen (O ₂) $M_r = 31.9988$	288.15	2.756×10^{-5}	$A = -66.7354$	5
	293.15	2.501×10^{-5}	$B = 87.4755$	
	298.15	2.293×10^{-5}	$C = 24.4526$	
	303.15	2.122×10^{-5}	Std. dev. = $\pm 0.36\%$	
	308.15	1.982×10^{-5}	Temp. range = 273.15–348.15	
Ozone (O ₃) $M_r = 47.9982$	293.15	$1.885 \times 10^{-6} \pm 10\%$ pH = 7.0	Experimental value derived from Henry's Law Constant Equation	5
Nitrogen (N ₂) $M_r = 28.0134$	288.15	1.386×10^{-5}	$A = -67.3877$	6
	293.15	1.274×10^{-5}	$B = 86.3213$	
	298.15	1.183×10^{-5}	$C = 24.7981$	
	303.15	1.108×10^{-5}	Std. dev. = $\pm 0.72\%$	
	308.15	1.047×10^{-5}	Temp. range = 273.15–348.15	
Nitrous oxide (N ₂ O) $M_r = 44.0129$	288.15	5.948×10^{-4}	$A = -60.7467$	7
	293.15	5.068×10^{-4}	$B = 88.8280$	
	298.15	4.367×10^{-4}	$C = 21.2531$	
	303.15	3.805×10^{-4}	Std. dev. = $\pm 1.2\%$	
	308.15	3.348×10^{-4}	Temp. range = 273.15–313.15	
Nitric oxide (NO) $M_r = 30.0061$	288.15	4.163×10^{-5}	$A = -62.8086$	7
	293.15	3.786×10^{-5}	$B = 82.3420$	
	298.15	3.477×10^{-5}	$C = 22.8155$	
	303.15	3.222×10^{-5}	Std. dev. = $\pm 0.76\%$	
	308.15	3.012×10^{-5}	Temp. range = 273.15–358.15	
Carbon monoxide (CO) $M_r = 28.0104$	288.15	2.095×10^{-5}	Derived from Henry's Law Constant Equation	8
	293.15	1.918×10^{-5}	Std. dev. = $\pm 0.043\%$	
	298.15	1.774×10^{-5}	Temp. range = 273.15–328.15	
	303.15	1.657×10^{-5}		
	308.15	1.562×10^{-5}		
Carbon dioxide (CO ₂) $M_r = 44.0098$	288.15	8.21×10^{-4}	Derived from Henry's Law Constant Equation	9
	293.15	7.07×10^{-4}	Std. dev. = $\pm 1.1\%$	
	298.15	6.15×10^{-4}	Temp. range = 273.15–353.15	
	303.15	5.41×10^{-4}		
	308.15	4.80×10^{-4}		
Hydrogen selenide (H ₂ Se) $M_r = 80.976$	288.15	1.80×10^{-3}	$A = 9.15$	10
	298.15	1.49×10^{-3}	$B = 974$	
	308.15	1.24×10^{-3}	$C = -3.542$ $D = 0.0042$ Std. dev. = $\pm 2.3 \times 10^{-5}$ Temp. range = 288.15–343.15	
Hydrogen sulfide (H ₂ S) $M_r = 34.082$	288.15	2.335×10^{-3}	$A = -24.912$	10
	293.15	2.075×10^{-3}	$B = 3477$	
	298.15	1.85×10^{-3}	$C = 0.3993$	
	303.15	1.66×10^{-3}	$D = 0.0157$	
	308.15	1.51×10^{-3}	Std. dev. = $\pm 6.5 \times 10^{-5}$ Temp. range = 283.15–603.15	
Sulfur dioxide (SO ₂) $M_r = 64.0648$	288.15	3.45×10^{-2}	$A = -25.2629$	11
	293.15	2.90×10^{-2}	$B = 45.7552$	

Gas	T/K	Solubility (X_1)	Equation constants	Ref.
	298.15	2.46×10^{-2}	$C = 5.6855$	
	303.15	2.10×10^{-2}	Std. dev. = $\pm 1.8\%$	
	308.15	1.80×10^{-2}	Temp. range = 278.15—328.15	
Chlorine (Cl_2) $M_r = 70.9054$	283.15	$2.48 \times 10^{-3} \pm 2\%$	Experimental data	11
	293.15	$1.88 \times 10^{-3} \pm 2\%$	Temp. range = 283.15—333.15	
	303.15	$1.50 \times 10^{-3} \pm 2\%$		
	313.15	$1.23 \times 10^{-3} \pm 2\%$		
Chlorine monoxide (Cl_2O) $M_r = 86.9048$	273.15	$5.25 \times 10^{-1} \pm 1\%$	Experimental data	11
	276.61	$4.54 \times 10^{-1} \pm 1\%$	Temp. range = 273.15—293.15	
	283.15	$4.273 \times 10^{-1} \pm 1\%$		
	293.15	$3.353 \times 10^{-1} \pm 1\%$		
Chlorine dioxide (ClO_2) $M_r = 67.4515$	288.15	2.67×10^{-2}	$A = 7.9163$	11
	293.15	2.20×10^{-2}	$B = 0.4791$	
	298.15	1.823×10^{-2}	$C = 11.0593$	
	303.15	1.513×10^{-2}	Std. dev. = $\pm 4.6\%$	
	308.15	1.259×10^{-2}	Temp. range = 283.15—333.15	
Methane (CH_4) $M_r = 16.0428$	288.15	3.122×10^{-5}	$A = -115.6477$	12
	293.15	2.806×10^{-5}	$B = 155.5756$	
	298.15	2.552×10^{-5}	$C = 65.2553$	
	303.15	2.346×10^{-5}	$D = -6.1698$	
	308.15	2.180×10^{-5}	Std. dev. = $\pm 0.056\%$ Temp. range = 273.15—328.15	
Ethane (C_2H_6) $M_r = 30.0696$	288.15	4.556×10^{-5}	$A = -90.8225$	13
	293.15	3.907×10^{-5}	$B = 126.9559$	
	298.15	3.401×10^{-5}	$C = 34.7413$	
	303.15	3.002×10^{-5}	Std. dev. = $\pm 0.13\%$	
	308.15	2.686×10^{-5}	Temp. range = 273.15—323.15	
Propane (C_3H_8) $M_r = 44.097$	288.15	3.813×10^{-5}	$A = -102.044$	14
	293.15	3.200×10^{-5}	$B = 144.345$	
	298.15	2.732×10^{-5}	$C = 39.4740$	
	303.15	2.370×10^{-5}	Std. dev. = $\pm 0.012\%$	
	308.15	2.088×10^{-5}	Temp. range = 273.15—347.15	
Butane (C_4H_{10}) $M_r = 58.123$	288.15	3.274×10^{-5}	$A = -102.029$	14
	293.15	2.687×10^{-5}	$B = 146.040$	
	298.15	2.244×10^{-5}	$C = 38.7599$	
	303.15	1.906×10^{-5}	Std. dev. = $\pm 0.026\%$	
	308.15	1.645×10^{-5}	Temp. range = 273.15—349.15	
2-Methyl propane (Isobutane) (C_4H_{10}) $M_r = 58.123$	288.15	2.333×10^{-5}	$A = -129.714$	14
	293.15	1.947×10^{-5}	$B = 183.044$	
	298.15	1.659×10^{-5}	$C = 53.4651$	
	303.15	1.443×10^{-5}	Std. dev. = $\pm 0.034\%$	
	308.15	1.278×10^{-5}	Temp. range = 278.15—318.15	

References

- C. L. Young, Ed., *IUPAC Solubility Data Series*, Vol. 5/6, Hydrogen and Deuterium, Pergamon Press, Oxford, England, 1981.
- H. L. Clever, Ed., *IUPAC Solubility Data Series*, Vol. 1, Helium and Neon, Pergamon Press, Oxford, England, 1979.
- H. L. Clever, Ed., *IUPAC Solubility Data Series*, Vol. 4, Argon, Pergamon Press, Oxford, England, 1980.
- H. L. Clever, Ed., *IUPAC Solubility Data Series*, Vol. 2, Krypton, Xenon and Radon, Pergamon Press, Oxford, England, 1979.
- R. Battino, Ed., *IUPAC Solubility Data Series*, Vol. 7, Oxygen and Ozone, Pergamon Press, Oxford, England, 1981.
- R. Battino, Ed., *IUPAC Solubility Data Series*, Vol. 10, Nitrogen and Air, Pergamon Press, Oxford, England, 1982.
- C. L. Young, Ed., *IUPAC Solubility Data Series*, Vol. 8, Oxides of Nitrogen, Pergamon Press, Oxford, England, 1981.
- R. W. Cargill, Ed., *IUPAC Solubility Data Series*, Vol. 43, Carbon Monoxide, Pergamon Press, Oxford, England, 1990.
- R. Crovetto, Evaluation of Solubility Data for the System $\text{CO}_2\text{-H}_2\text{O}$, *J. Phys. Chem. Ref. Data*, 20, 575, 1991.

10. P. G. T. Fogg and C. L. Young, Eds., *IUPAC Solubility Data Series*, Vol. 32, Hydrogen Sulfide, Deuterium Sulfide, and Hydrogen Selenide, Pergamon Press, Oxford, England, 1988.
11. C. L. Young, Ed., *IUPAC Solubility Data Series*, Vol. 12, Sulfur Dioxide, Chlorine, Fluorine and Chlorine Oxides, Pergamon Press, Oxford, England, 1983.
12. H. L. Clever and C. L. Young, Eds., *IUPAC Solubility Data Series*, Vol. 27/28, Methane, Pergamon Press, Oxford, England, 1987.
13. W. Hayduk, Ed., *IUPAC Solubility Data Series*, Vol. 9, Ethane, Pergamon Press, Oxford, England, 1982.
14. W. Hayduk, Ed., *IUPAC Solubility Data Series*, Vol. 24, Propane, Butane and 2-Methylpropane, Pergamon Press, Oxford, England, 1986.